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RECENT DEVELOPMENTS IN LIGHT ALLOYS.

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BUREAU OF STANDARDS.

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## RECENT DEVELOPMENTS IN LIGHT ALLOYS.

By

R. W. Woodward,  
Bureau of Standards.

This report is intended to cover the progress that has been made in both the manufacture and utility of light alloys in the United States since the first part of 1919. Much of this progress is the result of investigations either started during the war period and completed since the declaration of the armistice or of work that has been a natural consequence from experience gained during the war.

Of those light aluminum alloys which can be worked, duralumin or material of similar composition, because of its inherent possibilities is probably the most widely used and naturally has received the most attention at the hands of investigators. Dr. Merica and his associates at the Bureau of Standards have greatly increased our knowledge of the manufacture and heat treatment of duralumin. It has shown\* that it was advisable to preheat the ingots previous to rolling somewhat higher than was customary, namely to preheat to  $500^{\circ}\text{C}$  and then roll at  $450^{\circ}\text{C}$ . The best quenching temperature was found to lie between  $510$  and  $515^{\circ}\text{C}$  and quenching should be in hot water.

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\* "Heat treatment of Duralumin," Bureau of Standards Scientific Paper No. 347, by P. D. Merica, R. G. Waltenberg, and H. Scott.

The mechanical properties of the finished material are quite dependent upon the artificial ageing process, but for most purposes it was found best to age at 100°C for about five to six days.

A theory of the mechanism of the hardening of duralumin was developed and this theory has been further amplified by Jeffries\*.

Duralumin may also be drop forged as well as rolled and some interesting tests on drop forged connecting rods are given by Rollason\*\* who found that the aluminum alloy rods withstood impact fatigue better than ordinary steel forgings.

Gibson\*\*\* has also investigated the fatigue resistance of various duralumins and concludes that weight for weight forged and heat-treated duralumin is equal to, if not superior to forged steel in its fatigue resisting properties. He also states that under certain limitations as to stresses involved that it is comparable with steel on a volume for volume basis.

As an example of the increasing use of duralumin there might be cited the all-metal planes such as the Larsen or others similar to the German Junker models. These planes use duralumin for wing surface coverings in place of fabric as well as for structural members. For the latter purpose seamless tubing is essential although to date has not been satisfactorily produced in this country. In Europe it is

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\* "Ageing of Duralumin"; Zay Jeffries, Journal Institute of Metals, Vol. 2, 1919.

\*\* "Increasing Use of Alloyed Aluminum as an Engineering Material"; G. M. Rollason, Industrial Management, 59:456 (1920).

\*\*\* "Fatigue and Impact Fatigue Tests of Aluminum Alloys"; W. A. Gibson; Proceedings of American Society for Testing Materials, 1920.

made by the extrusion process and the manufacturers in this country have promised to develop methods to produce similar tubing.

Many of the light casting alloys have been studied by Merica and Karr\* who determined the tensile properties, hardness, resistance to corrosion and resistance to the action of alternating stresses of a number of compositions. The effect of various additional elements such as copper, zinc, manganese, magnesium and nickel were studied and these investigators showed that certain of the casting alloys were also subject to beneficial results from heat treatment. This practice was commended to the manufacturers of castings for realization of its commercial possibilities.

Jeffries and Gibson\*\* also investigated the effect of heat treatment upon cast aluminum alloys and suggested that more uniform results could be obtained by heating the castings in a bath of fused niter followed by quenching in oil, thus reducing to a minimum the tendency for the atmosphere to permeate and oxidize the interior of porous castings.

R. J. Anderson\*\*\* has published several articles on aluminum castings and foundry practice, particularly with a view of producing sound

\* "Tests of Light Casting Alloys"; Merica and Karr, Bureau of Standards. Technologic Paper No. 139. Also "Proceedings of the American Society for Testing Materials," Vol. 19, Part II, p.297 (1919).

\*\* "Heat Treatment of Aluminum Alloy Castings"; Bulletin of American Institute of Mining and Metallurgical Engineers, 153:2493 (1919).

\*\*\* "Casting Losses in Aluminum"; Metal Industry, 19:318 (1920).

"Blowholes, etc., in Aluminum Alloy Castings"; Bureau of Mines Technologic Paper 241 (1919).

"Aluminum Rolling Mill Practice"; Chemical and Metallurgical Engineering, 22:489 (1920).

"Unsoundness of Aluminum Castings"; Foundry, 47:579 (1919).

castings, free from blowholes and hard spots.

The metallography of aluminum and its alloys has also received some attention; Merica, Waltenberg, and Freeman\* studied aluminum and its alloys with copper and with magnesium. The various constituents were identified and the temperature solubility curves of  $\text{CuAl}_2$  and of  $\text{Mg}_2\text{Al}_3$  determined. Anderson\*\* studied the metallography of commercial aluminum and aluminum in ingot form and compared the microstructure, macrostructure, and fracture of tough and brittle ingots.

For a comprehensive investigation of the constitution of and positive identification of the constituents in aluminum it is necessary to start with pure aluminum. The best aluminum now obtainable is seldom better than 99.8% pure. The Bureau of Standards has lately endeavored to produce aluminum of greater purity but so far has been unsuccessful and the work has been temporarily discontinued due to lack of personnel.

The corrosion of the rolled light alloys was investigated by Merica, Waltenberg, and Finn\*\*\* using three ternary series Al - Mg - Cu,, - Al - Mg - Mn, and Al - Mg - Ni. The alloys of the Al - Mg - Mn series resisted corrosion in general better than the others.

Hard rolled commercial aluminum corrodes much more than any of the

\* "Constitution and Metallography of Aluminum and its Light Alloys with Copper and with Magnesium"; Merica, Waltenberg, and Freeman, Bureau of Standards Scientific Paper No. 337 (1919).

\*\* "Metallography of Aluminum Ingots"; R. J. Anderson, Chemical and Metallurgical Engineering, 21:229 (1919).

"Metallography of Aluminum," R. J. Anderson; Journal Franklin Institute, 187:1 (1919).

\*\*\* "Mechanical Properties and Resistance to Corrosion of Rolled Light Alloys of Aluminum and Magnesium with Copper, with Nickel and with Manganese"; Merica, Waltenberg, and Finn, Bureau of Standards Technologic Paper 132 (1919).

alloys, annealed aluminum was more resistant to corrosion than the hard rolled aluminum, but did not compare favorably with the alloys. This paper also gives the mechanical properties of the various alloys in the cold rolled, annealed and heat-treated conditions.

The Bureau of Standards, in cooperation with the Navy Department (work unpublished), also conducted tests on the corrosion of aluminum and its alloys by sea water both unprotected and with various protective coatings. Presence of oil on the water where the plates were exposed lends some doubt to the results but the indications were that unprotected duralumin has practically the same resistance to corrosion as that which has been protected. Other findings were practically as above.

Among the new light alloys which have been brought out "Dow Metal" is quite interesting. This alloy is said\* to contain over 90% magnesium and to have a specific gravity of 1.79. Castings have a tensile strength of from 22,000 to 25,000 lbs. per square inch; yield point, 12,000 to 14,000 lbs. per square inch; elongation 3.5% in 2 inches; reduction of area 3.5%; and Brinell hardness of 55 to 75. The sand castings are subject to heat treatment, such procedure increases the tensile strength to 30,000 lbs. per square inch, and elongation and reduction of area to 6% each. The alloy may also be worked, drop forgings having a tensile strength of 50,000 lbs. per square inch and Brinell hardness of 70. No data is given in the literature on this alloy as to the method of casting which heretofore has been a great drawback in producing magnesium rich alloys due to the affinity of magnesium for oxygen,

nitrogen, etc.; Waltenberg and Coblenz\*\* in preparing aluminum magnes-

\* "Magnesium Alloy"; E. J. Jenkins, Iron Age 106:193 (1920).

\*\* "Preparation and Reflective Properties of some Alloys of Aluminum with Magnesium and with Zinc"; Bureau of Standards Scientific Paper No. 363 (1920).

ium alloys resorted to vacuum casting in order to produce sound material.

In this connection an article by Thomas on the casting of Elektron-metal containing about 80% magnesium and the balance aluminum and zinc, it is stated\* that great care must be exercised in selecting the sand for molding and that the molds must be thoroughly dried to get rid of all moisture. The alloy is melted in wrought iron or cast steel crucibles as magnesium will take up the silica of graphite crucibles. The crucible is covered with an iron cover to reduce oxidation, the pouring temperature must be closely controlled (just above melting point) and the melt poured directly after reaching the proper temperature. The alloy is brittle down to 100°C and the casting must not be disturbed until cold. He gives illustrations of very sound castings produced in this manner.

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\* Uber das Vergiesen von Elektrometall, Felix Thomas, Stahl und Eisen, 40:290 (1920).